

State during the last decade put a stop to all farming work and there was very little being done on the farm at the close of the month. The rain and snow during the latter part of the month put an excellent season in the ground, and with favorable weather farming operations will be rushed. The warm weather during the first and second decades of January was exceptionally favorable for the wheat crop, and prospects for a good crop were never better, but the cold weather, with temperatures near zero over the wheat belt during the latter part of the month, damaged the crop to some extent, especially where the ground was not covered with snow. It is believed that with favorable weather the plant will come out and recover from the effects of the damage sustained by the severe cold weather and a fair crop will yet be made.—*I. M. Olive.*

Utah.—The mean temperature was 26.1°; the highest was 68°, at Frisco on the 6th, and the lowest, 24° below zero, at Fort Du Chesne on the 26th. The average precipitation was 1.53; the greatest monthly amount, 3.80, occurred at Grover, and the least, 0.20, at Woodruff.—*J. H. Smith.*

Virginia.—The mean temperature was 32.7°, or 4.2° below normal; the highest was 70°, at Ashland and Petersburg on the 4th, and the lowest, 15° below zero, at Bristol on the 28th and at Big Stone Gap on the 30th. The average precipitation was 1.94, or 2.44 below normal; the greatest monthly amount, 5.00, occurred at Manassas, and the least, 0.90, at Buckingham and Stanleytown. The month was generally mild

and pleasant until the 25th, when a period of cold and stormy weather prevailed, which was unusual for this section. Ice thick enough for harvesting formed in nearly every portion of the State, while sufficient snow to yield good sleighing fell generally.—*E. A. Evans.*

Washington.—The mean temperature was 34.8°, or 0.5° above normal; the highest was 62°, at Dayton on the 22d, and the lowest, 15° below zero, at Waterville on the 26th. The average precipitation was 4.28, or 1.10 below normal; the greatest monthly amount, 15.56, occurred at Clearwater, and the least, 0.83, at Sunnyside.—*G. N. Salisbury.*

West Virginia.—The mean temperature was 28.8°, or about 4.0° below normal; the highest was 69°, at Point Pleasant on the 3d, and the lowest, 18° below zero, at Beckly on the 26th. The average precipitation was 1.70, or 1.50 below normal; the greatest monthly amount, 2.85, occurred at Beverly, and the least, 0.90, at White Sulphur Springs.—*H. L. Ball.*

Wisconsin.—The mean temperature was 15.4°, or 1.4° above normal; the highest was 66°, at Prairie du Chien on the 1st, and the lowest, 38° below zero, at Osceola Mills on the 26th. The average precipitation was 1.98, or 0.70 above normal. The greatest monthly amount, 4.11, occurred at Sharon, and the least, 0.19, at Oshkosh.

Wyoming.—The mean temperature was 1.95, or about normal; the highest was 62°, at Fort Laramie on the 9th, and the lowest, 32° below zero, at Sheridan on the 26th. The average precipitation was 0.55, or about normal; the greatest monthly amount, 2.00, occurred at Sundance, and the least, 0.12, at Fort Washakie.—*M. G. Kenoe.*

RIVER AND FLOOD SERVICE.

By PARK MORRILL, Forecast Official, in charge of River and Flood Service.

The extreme and average stages of water in the rivers for the current month are given in the following table. Heavy rains and higher rivers are reported in the Ohio Valley but little damage has occurred. The Upper Mississippi and the Ohio were closed to navigation by ice at the end of the month.

The following résumé of river stages and conditions of navigation in the respective streams is compiled from reports by the officials of the Weather Bureau at various river stations and section centers:

Hudson River.—On the first day of January an average of 4 inches of snow covered the watershed area of the Hudson. The mild temperatures of the first four days of the month reduced this depth, and by the 12th practically no snow remained on the ground. The storms of the week ending January 25, which passed down the St. Lawrence Valley, covered the watershed with from 3 to 6 inches of snow, and this was increased by the close of the month to an average of 9 inches on the upper Hudson watershed and 3 inches on the lower watershed area. The foggy and warm conditions of the first week of January honeycombed the ice in the upper Hudson and caused the ice in the river south of Newburg to disappear. During the second week the ice in the harvesting districts was soft and filled with many small holes. Floating ice was observed in the river at Newburg. The thaw of the third week softened the upper Hudson ice and broke up the Lower Hudson fields from Poughkeepsie southward. By the 25th new ice fields formed in the lower Hudson to the thickness of from 3 to 5 inches and those of the upper Hudson received some accretion. The average depth of frost in the ground is 3 feet. The weather and temperature conditions of the Hudson River district during the month were variable, and as a result, the close of the month finds the river ice not in the best condition for housing, except in the northern districts.

Susquehanna River and branches.—No floods occurred in the Susquehanna or any of its branches during the month. Although the rainfall for January averaged, for all reporting stations, double the amount for December the average reading of the gauges for January was slightly lower than that for the preceding month. This was doubtless due to the colder weather of January which caused many of the smaller streams to freeze and the water ordinarily contributed by many springs to be cut off by freezing soon after leaving its source and spread out into sheets of ice, which will continue to expand until the weather moderates and a general thaw releases the water from its frozen state. At Cameron, on Driftwood Creek, the most northwesterly station on the West Branch of the Susquehanna, the stream, which was frozen over on December 27, opened on January 2, but closed again on the 13th and remained closed the rest of the month; at Driftwood, the next station south, the branch had not yet closed at the end of January. At Sinnemahoning, the next point of observation, the water was below zero of the gauge all the month. Cedar Run reports ice from the 10th to the 16th, and again from the 24th to the 31st, with gauge readings below zero all the month. At Keating the river was closed from the 24th to the 31st, and at Renova it froze over December 24 and re-

mained closed till January 5, was opened from the 6th to the 13th, and closed again from the 14th to the 31st. The river at Farrandville was closed during the whole month while at Lock Haven and Williamsport no ice was reported. The Juniata, at Mifflin closed for the second time this winter on January 12, while at Huntingdon no ice has yet been reported. On the North Branch the river at East Bloomsburg continued at a uniform stage of a little over 2 feet except on the 6th, when a rise of 1.5 feet occurred, followed by a fall of 1 foot on the 7th. Perhaps the most interesting feature of the month was the sudden fall of over a foot at Harrisburg on the 26th and the sharp rise on the 27th. Floating ice was observed on the river from the 1st to the 26th in greater or lesser quantities nearly every day and at times sufficient to cover the whole surface. On the 25th and 26th, when the temperature fell almost to the zero point, the freezing of the springs and streams above Harrisburg suddenly cut off an enormous quantity of water, thus causing a marked fall at Harrisburg. On the following day, owing probably to a considerable volume of water which had been temporarily held in check having been released by warm currents from springs forcing an outlet beneath the ice and possibly to back water from gorges, the river rose higher than it registered before the surface was frozen. At the close of the month the ice averaged 8 inches in thickness at Harrisburg. In the main channel the ice is very rough, having been formed by the gorging of floating ice when the river closed, which occurrence took place at about 4 a. m. on January 27. The ice at Columbia broke up and moved out on January 5, the river having been closed since Christmas night; but it closed again during the month, and at the end of January transfers of passengers were being made by sleighs between Columbia and Wrightsville instead of by the ferry boats which have been in use since the destruction of the bridge by the hurricane of September 29 and 30, 1896.

Rivers of the South Atlantic States.—Owing to the scarcity of precipitation during the month, the James River, already low from deficient rainfall, continued to fall slowly until the 11th, when it reached the lowest point recorded this winter, 0.2 foot below zero of gauge. From this time until the last decade of the month it remained stationary. On the 20th a slight rise occurred under the influence of precipitation occurring at points on the upper watershed, but this was soon checked by freezing weather, which prevented drainage and locked up the tributary streams. This condition lasted until the close of the month, with the river falling slowly. The water was remarkably clear and free from impurities all of the month. Ordinarily any appreciable precipitation in the Rivanna basin will cause that stream to pour a volume of muddy water into the James, which will discolor it for a week or more, and that such was not the case with the precipitation of the 27th and 28th was due to the drainage being stopped by the cold weather prevailing at the time.

The rivers of North Carolina continued low during the greater portion of January. No floods or even sudden and threatening rises occurred. The precipitation occurring from the 1st to the 4th and on the 13th, 14th, and 17th was too small to cause material changes in the stages of the rivers. The heavier rainfall of the 20th and 21st, however, caused a rapid rise on the 22d in the eastern portion of the State, reaching 10 feet in the Cape Fear River, altogether a beneficial rise. The stages resumed their low level at the end of the month, and the

upper courses of all the streams were frozen during the severe cold wave of the 26th to 30th.

All streams in South Carolina remained at a very low stage until the 18th, when they were checked in their downward tendency by the moderate rains of the 14th to 17th. The heavy rains in the upper watersheds of the Wateree and Pedee caused a rise of 9 feet at Camden and 17 feet at Cheraw, thus allowing much freight to be sent down these streams. Ice was running lightly on the Wateree, the upper Pedee, the Lumber, the Little Pedee, the Waccamaw, the Lynch, and the upper Edisto rivers on the 28th to 31st, without injury to navigation. The rivers at Camden and Cheraw were frozen near the shores, to a thickness of 4 inches, on the 28th to 30th. This ice moved down stream on the 31st, without any injurious results so far as heard from. The light snowfall over the northwestern portion of the State on the night of the 27th melted slowly during the 29th and 30th and did not raise the streams over that section to any appreciable extent. The Wateree was navigable from the mouth of the Santee up to Camden during the entire month. The Pedee from Smiths Mills to Cheraw was navigable only from the 20th to the 31st; from the 1st to the 19th it was below a 3-foot stage. On the lower Pedee, from Georgetown to Smiths Mills, navigation was uninterrupted throughout the month. On the Congaree, below Granby, there was sufficient water for navigation purposes. Practically no logging was done upon the Edisto until the 21st, after which date much of the timber cut several months before was successfully rafted downstream. The observer at Kingstree, on the Black River, reports that during the last decade of the month upwards of 120 rafts were sent past that place to Georgetown.

The Savannah River continued at a nearly normal stage until the 15th, when a rise of 5.6 feet occurred at Augusta, due to heavy rains in the lower watershed of the up-river country. After that there were irregular changes in the river stages until the 26th, when, on account of heavy rains over the greater portion of the Savannah Valley, a 24-hour rise of 10.6 feet was recorded. At no time during the month was the river low enough to hinder navigation, nor was it sufficiently high to interfere with the regular boat traffic or endanger the river bottom lands.

No great changes occurred in the other Georgia rivers during the month. The most notable feature was the continued low stage of the water. It was stated by several observers that the water has averaged lower than for any January during the past twenty-five years, and this statement is borne out by the Weather Bureau records. The low stage of water in the rivers of this section is due to the marked deficiency in rainfall throughout their drainage areas during the past year. The most decided changes during the month were a rise of 6.2 feet in the Chattahoochee at Eufaula on the 20th and of 5.2 feet on the same date in the Oostahaula at Resaca. These rises were due to heavy rains in the vicinity of the stations, which are shown to be purely local by the sudden and short duration of the rises, these lasting less than twenty-four hours. Floating ice was noticed in the Oostahaula at Resaca on the 28th, and during the last three days of the month the river was frozen entirely across, but the ice was not of sufficient strength to support the weight of a man. The same was true on the same river at Rome, Ga., on the 30th and 31st. The Chattahoochee, which is navigable when the gauge at Columbus shows 2 feet, was open to navigation from the 16th to the 27th of the month.

Mobile River and branches.—The Alabama River and tributaries were low during the first half of the month, when the rains were so light and scattered as to hardly affect the rivers, and barely navigable stages existed as far up as Selma, above which point there was but a barge-water stage. General and heavy rains over the Alabama watershed on the 14th and 15th gave higher rivers than at any time since last March, and good navigable stages prevailed during the last half of the month, though the highest water at Montgomery was not more than the average January stage. Intensely cold weather prevailed over this section from the 26th to 30th, when the ground was frozen, but no ice worthy of mention formed in the rivers, except at Rome, Ga., on the 30th, when the river at that point was nearly covered with ice. River men agree that the protracted period of low water which prevailed in the rivers of this section through most of last summer and fall and up to the middle of January is without precedent in the last twenty-five years, and that, in consequence, thousands of bales of cotton which would have been handled cheaply by river had to be hauled many miles to the railroads.

The Tombigbee River and tributaries remained at unusually low stages the greater portion of the month. The rain which fell, while causing marked rises in all the rivers, was at such intervals that navigation was aided but little, owing to the fact that while the rivers rise rapidly from the effect of a general rain, yet if not reinforced at short periods it runs off as rapidly. The rain on the 1st, reinforced by the heavy rain over the State during the 3d, caused continued though moderate rises in all the rivers until the 7th. From this time the rivers changed but slightly until the 11th, when a general fall occurred to the 14th. General and moderately heavy rain on the 15th to 18th caused decided rises in the lower Tombigbee until the 22d, followed by falling water from the 23d to the close of the month. The following clipping from the Mobile Daily Register for January 14, 1897, is

interesting: "The steamboat *Hard Cash* failed to go as high as Demopolis on her last week's trip on account of low water. We doubt if the oldest resident on the Tombigbee River remembers as low a stage of water in the month of January as exists at this time. We feel certain that it has not been the case for fifty years. In the winter of 1854-55 the river did not get in good boating order at any time during the season, but larger boats than any on the river at this time went as high as Demopolis the whole season."

Ohio River and branches.—During the greater part of the month large quantities of ice were passing out through the Alleghany at Pittsburg while the Monongahela remained comparatively clear, due, no doubt, to its more southerly origin. As the colder weather of the latter part of the month approached, however, ice began to form rapidly in both streams and their tributaries and navigation closed entirely on the 25th. For the remainder of the month the rivers were entirely closed by the ice, the harbor alone being kept clear by the ice-boats as far upstream as the first dam in each river. At the end of the month about 5,000,000 bushels of coal bound for southern ports lay in the Pittsburg harbor awaiting the opening of the upper Ohio.

In the earlier part of the month navigation was unimpeded at Parkersburg, save for a day or two following the 13th, on which date the mountain rivers were frozen over. This ice was broken up on the next day and was carried down the Ohio during the 14th and 15th, and slightly interfered with navigation on that river. The Ohio during this period was unusually free from obstructions, and the prevailing good stages of water gave excellent opportunity for boating. The severe cold wave during the last decade closed navigation on the 25th, and it so remained at the end of the month. Ice formed on the rivers to a thickness of from 4 to 6 inches, on still water to a thickness of from 6 to 8 inches.

The remarkably good stage of water and the unusual activity in river traffic at Cincinnati for the winter season continued until January 27, when navigation was suspended on account of increasingly heavy floating ice and the fear of a freeze-up. The timely Weather Bureau warnings of the approach of colder weather, the gradually increasing severity of the cold, the persistent duration of very low temperature from the 23d to the 30th, and the fair stage of water carrying along the rapidly moving floes of ice afforded the opportunity to prepare against an anticipated closing of the river. Notwithstanding the severe weather during the latter part of the month, which caused complete suspension of river traffic, the supply of coal is abundant. With the exception of the *City of Louisville*, which on the 28th of the month fought her way through the floating ice with some trifling damage to her wheel buckets back from Louisville to Cincinnati where she tied up, there was no steam navigation between Louisville and Pittsburg after the 27th of the month. The floating ice has caused the loss of about one week between Cincinnati and Louisville and about 10 days in the upper river. At Cincinnati the harbor boats have broken up the great ice floes, in which they were materially assisted by the numerous bridge piers, and steamers secured to the banks have kept their wheels revolving. No loss or damage has been sustained. Ice is estimated at from 3 to 4 inches in thickness on the river; in neighboring ponds and lakes it is from 5 to 6 inches thick. Gorges were formed at various points up the river and on the 31st a partial gorge formed against the southern piers of the upper bridge, that of the Louisville and Nashville Railway, at this point. This was considered as favorable for the harbor. With the approaching warmer and rainy weather it is believed that the ice will be carried away without damage to river craft and river men are exerting great activity in view of the resumption of navigation.

At Louisville the stages of water in both the Ohio and Kentucky rivers were very favorable for traffic up to the 26th. While the greater part of the winter's supply of coal had arrived, some belated fleets came in during the month and the usual traffic was not interrupted until the above date, when navigation was impeded to some extent by the thin ice which formed under the influence of the cold wave. On the 27th the river was full of floating ice, which caused the partial suspension of navigation. From the 28th to the close of the month the ice formed a dense pack, which extended from the falls to a distance of several miles above the city and caused a total suspension of navigation; not even the ferry boats plying between Louisville and Jeffersonville were able to force their way through the mass. The boats in the harbor sought refuge in the canal and extraordinary precautions were taken to prevent the coal fleets moored above the city from being swept away when the ice breaks. The same conditions obtained in the Kentucky river, where extensive rafts of logs are endangered. Several boats have been caught in the ice and apprehension is felt for their safety.

An ice gorge, 18 miles in length, formed in the Ohio at Evansville on the 11th, and, by damming the river, caused the current to flow across the country from a point above that city, reentering the channel near Henderson. Serious apprehension was felt for a time that the river would be permanently diverted, but the gorge gave way on the next day and the ice passed out.

At Cairo the river at the 1st of the month was falling, but came to a stand by the morning of the 4th. An unusually rapid rise in the Mississippi, starting in at St. Louis on the 3d, commenced to be felt at Cairo on the 5th, and backed the water up the Ohio, causing a rise at

Cairo of 16.8 feet during the subsequent five days. From the morning of the 5th to the morning of the 6th the river rose 8.2 feet, and this rise also affected the river as far up as Paducah, Ky., where the stage of water increased 8.0 feet from the 5th to the 9th. No very marked changes in height of water occurred at Evansville during the month, and a good stage was maintained from Evansville down. Ice began forming in the river at Evansville on the 26th and all boats sought harbor in Green River. Heavy floating ice on the 29th caused complete suspension of navigation, and ice was piled 3 or 4 feet high along the levee. No boats were running at Evansville at the end of the month. At Cairo on the 27th, on account of heavy floating ice in the Mississippi, all packets and freight boats went to the bank. Heavy floating ice was present in the Ohio from the 29th to the 31st, during which time navigation was suspended. Transfer boats continued to transfer trains across the Ohio, but those that run to Birds Point, Mo., could not make landings at the inclines and had to transfer passengers without the cars. Many boats and barges were transferred to the Kentucky shore at East Cairo, where there is the best ice harbor between Cairo and Paducah on the Ohio and Chester and Memphis on the Mississippi.

During the first fifteen days of the month navigation was closed on the upper Tennessee to all large boats and on the Clinch River to all boats because of low water. On the 3d and 4th rain fell over the watershed, ranging from one to three-fourths of an inch, but had very little effect on the river; on the 13th rain began and continued, with from one to two days' intermission, up to the 21st, causing the river to rise and opening navigation to all boats on the 14th. The river men state that very little business was done the first half of the month on account of low water, and at the end of the month business was suspended on account of the running ice. At Loudon navigation was suspended throughout the month from low water and ice. No boats entered the Clinch River after the 27th on account of ice, which began to form at Kingston that day, and on the 28th the ice was coming together and lodging fast. The Tennessee River had floating ice from the evening of January 29 to morning of January 31 from Riverton to Knoxville. Much ice was passing Loudon from the 27th to 31st. The Hiwassee had running ice from the 28th to 31st. Ice formed along the shores at Chattanooga and Bridgeport on the 29th and at Chattanooga on the 30th. The ice was 2 inches thick and extended 15 feet from shore. The running ice ceased to pass Chattanooga during the 31st, and the river men feared that an ice gorge was forming and would not send out their boats until further information could be obtained. On the 30th the Clinch was frozen over at Clinton, and on January 30th, for the first time in ten years, the Duck River was frozen over at Centerville. The ice began to break up at Knoxville on the 30th and 31st. No damage occurred to any property on or along the river during the month. The great deficiency in rainfall during the past three months has been very unfavorable to boating interests on the Tennessee River.

The month opened with low stages in the Cumberland River, but moderate rains on the 3d caused a steady but slow rise until the 9th. After this the river declined gradually until the 14th, when heavy general rains brought it up to a maximum of 21 feet at Nashville, 16 at Carthage, and 18 at Burnside. The balance of the month was characterized by a slow but steady fall. Floating ice was observed at Nashville and Carthage from the 29th to 31st. Navigation was suspended from the 1st to the 14th between Carthage and Burnside on account of low water, and between Nashville and Carthage from the 1st to 3d for the same cause. Boats ran to lower points all the month except on the 29th to 31st, when floating ice caused total suspension of navigation.

Mississippi River and minor branches.—The Mississippi and Minnesota rivers from St. Paul up to their sources remained frozen over all the month and gauge readings were impracticable, but from occasional inspection of the river it was apparent that the average stage of water ranged from 2.5 to 3.5 feet at St. Paul. These figures are estimated to be from 1 to 2 feet above the average January stage for the last ten years, and they certainly indicate 3 to 4 feet above that of the corresponding month of 1896, when the water was below zero of the gauge all the time. According to all reports, the lakes and marshes in the watersheds of these rivers have been replenished by the copious rains of 1896 and especially by the excessive precipitation of October and November, to an extent surpassing anything known since 1888. These reservoirs of water have been drying up and disappearing to an alarming extent for the past ten years; but now it is said that nearly all of them have been restored to the proportions that they presented in 1880-81, when water was very abundant and the maximum river gauge reading of 19.5 feet was registered at St. Paul (April 29, 1881). When the mild condition of last December is considered, with its frequent thaws, continuing into the early part of January, it is certain that a considerable part of the snow and ice over the watersheds of these rivers has been reduced to water, which has already passed off down the river. Hence, even though conditions approaching closely to those of the time of the great flood in 1881 exist, the chances of another one the coming spring are lessened.

The average date of the closing of the Mississippi at La Crosse is December 5, but this season the river did not freeze over until January 24. This is the latest date of closing since 1874. The river was frozen

nearly to the channel from the 1st to the 24th. The ice harvest began on the Mississippi River at this point on the 18th, and on the Black and La Crosse rivers on the 20th. The river in its present frozen condition affords an excellent road for farmers of the surrounding country to bring their produce to town, and in consequence business has been somewhat enlivened.

The river was open at Dubuque until the 22d and then froze over quickly, and by the 25th the ice near the channel was 5 to 8 inches thick. There was a steady rise at this point after the 12th, the river reaching 8.2 feet, a remarkable stage for this time of year and an unusually high stage for the river freezing, it being the highest of which there is any record. At Davenport the river remained open until the 27th. From 8 a. m. of the 26th to noon of the 27th the water rose 6.5 feet and reached a stage of 10 feet, due principally to an ice gorge forming below the city; the river froze over at that stage. This is also an unprecedented stage at time of freezing. The river froze over at Muscatine on the 26th, at which time it had reached a stage of 7.0 feet. It is thought that the freezing over of the river at this high stage is likely to cause ice gorges and very high water when the ice breaks up and goes out.

Floating ice was running at Keokuk from the 4th to the 16th, when the ice was dissolved by warm rains. New ice began forming on the 18th, growing steadily heavier until the river closed during the night of the 28-29th. Wherever excavations are made it is noticed that the ground is moist to a depth of 4 feet, while usually at this season the moisture extends but 6 or 7 inches. It might be inferred from this condition of the soil that less of the spring rains would be absorbed by the land and a greater amount be drained off into the water courses.

The severe storm which passed over the Mississippi Valley on the 2d and 3d caused an enormous amount of rain to fall in the Mississippi and lower Missouri watershed, the fall in Missouri and southern Illinois having been particularly excessive. The combined effects of the heavy rains in the Illinois, Mississippi, and Missouri valleys began to be felt at St. Louis on the 3d, and on the morning of the 4th the water marked 20 feet on the gauge, a rise of 13.2 feet in twenty-four hours and with one exception the greatest 24-hour rise in the history of the station. On January 7 a crest of 24.8 feet was reached, which is the highest recorded stage for the month of January, the next highest having been 17.5 feet on January 7 and 8, 1876, and on January 20, 1885. On the 5th the water broke through the cross levee at Willow Slough, a short distance from Quincy, and the surrounding country was submerged. The upper Illinois River Valley was also overflowed, the water at Peoria remaining above the danger line continuously from the 7th to 27th. Immense amounts of alluvial soil were brought down from the Missouri River, and a mud deposit of over 2 feet in thickness formed on the levee at St. Louis in twenty-four hours.

The first running ice of the month was reported at Burlington, Iowa, on the 4th, at Hannibal on the 5th, and at Louisiana, Mo., on the 6th, when the ferryboat at the latter place went into winter quarters. On the 8th the Mississippi at Hannibal was filled with running ice. By the 11th, owing to higher temperature, the ice had thinned out considerably as far south as Warsaw, but was still running heavy at Hannibal. On the 13th the river at the latter place was blocked at the bridge for a short time but soon commenced running again. On the 7th thin ice appeared at St. Louis but by evening had disappeared. On the 15th thin ice again commenced running past St. Louis but did not continue for more than a day. On the 24th ice commenced to run on the east side of the river at St. Louis and by the 25th was quite heavy. The Illinois River was frozen over at Beardstown on the 25th. On the 26th ice cutting was begun at Burlington and the river closed a few miles above Warsaw. On this date ice commenced running out of the Missouri River. Heavy ice continued running past St. Louis and navigation was suspended by the packet companies, although the transfer boats continued to make trips with the assistance of tugs. Navigation at St. Louis was totally suspended from the 27th to the 31st, and on the 28th the shore ice was over 4 inches in thickness. The ice commenced to thin out on the 29th, and by the 30th it was becoming soft and mushy. That the Mississippi was not gorged at many more places, and especially at St. Louis, was probably due to the swift current caused by the abnormally high stage of water.

Floating ice passed Chester from the 25th to the 31st and was observed at Cairo late in the afternoon of the 25th, becoming heavy by the morning of the 28th. Navigation was practically suspended on the Mississippi at Cairo after the 27th and continued closed at the end of the month.

The month opened with a fair stage of water south of Cairo. Between the 4th and 9th a rise of about 15 feet occurred at Cairo, which reached Memphis two days later, and Vicksburg five days after the flood crest had passed Memphis. A second and less important rise occurred between Memphis and Vicksburg from the 20th to the 28th, after which the water fell rapidly to the close of the month. The rapid rise in the river caused no serious inconvenience, except to a few contractors, who were engaged in removing sandbars, and the full volume of river traffic was kept up on the Mississippi and its tributaries until impeded by floating ice, which made its appearance at Mem-

phis on the 20th, at 5 a. m., and practically closed navigation in this section. The ice, which filled the entire navigable portion of the river, came in immense cakes, from 8 to 10 inches in thickness, and moved with great rapidity, making it extremely hazardous to attempt the movement of boats. Being warned three days in advance of the approach of the ice, boats northbound were turned back and tied in sheltered positions, and it is owing to these precautions that no serious damage occurred, the greatest loss being from the delay in shipment of freight.

Good boatable water existed in the Mississippi and its tributaries south of Memphis during the month for the most part; navigation on the upper White River, however, has been suspended, owing to low water. Considerable drift was reported in the Yazoo and running ice in the Mississippi as far south as Helena during the latter portion of the month, impeding navigation somewhat. The rise in the Mississippi was of great benefit at Vicksburg, especially to the lumber and coal interests, and it permitted boats to utilize the canal for landing at the city front, although much drift floated into the canal from the Mississippi during the rise. The tributaries are free from ice. The fluctuations in the river south of Vicksburg were confined to a general slight decline for the first ten days of the month, after which a marked rise of 5 feet occurred at New Orleans. The fluctuations at New Orleans after the 20th amounted to less than 2 feet, the highest water of the month occurring on the last day.

Heavy rains during the early part of the month caused marked rises in the Red River, Fulton showing a nearly 21-foot rise in the first week, Shreveport a 12-foot rise by the 10th, and Alexandria a 16-foot rise by the 21st. From June 15, 1896, to the beginning of January, 1897, with the exception of some days in December, navigation on the Red at Shreveport was practically suspended because of low water. Consequent upon the notable rains on the upper Red during the first few days of January, the river began to rise on the 3d, and by the 6th was of sufficient height at Shreveport to admit the *Valley Queen* (the largest steamer that ascends to this point) with a cargo of cotton, this being her first trip since April 30, 1896. The close of the month saw a falling river, but smaller craft plied without any trouble.

The fluctuations in the Onachita were marked, particularly in the upper river. Camden had a rise of 26 feet between the 2d and 7th, followed by a fall of 19 feet by the 16th, and a second rise of 16 feet by the 21st, after which there was a fall of 18 feet to the close of the month. A rise commenced at Monroe on the 2d, amounting to 13 feet by the 7th, after which the rise was gradual to the close of the month, reaching a total of nearly 22 feet.

Missouri River and branches.—The Missouri River and its tributaries above Sioux City continued frozen over throughout the month. From the beginning of the month to the 23d the river southward to Kansas City disclosed nothing of special interest, but on the 23d it was frozen over as far southward as the mouth of the Platte, and this condition continued the remainder of the month. At the close of the month the average thickness of ice on the river at Omaha was 12 inches.

A small quantity of floating ice appeared at Kansas City during the first days of the month, and a partial jam formed above the Hannibal bridge and in the mouth of the Kaw on the 6th, 7th, and 8th, giving way on the 9th upon the return of mild temperature. After this date there was a variable amount of floating ice until the 28th, when the river became blocked both above and below the bridge and remained so to the close of the month, with a quarter of a mile clear in the neighborhood of the bridge. The ice in the Kaw thickened much faster than in the Missouri, and is 7 inches thick at the end of the month.

On January 3 the Osage rose in twenty-four hours 17.9 feet to a 21-foot stage and reached a stage of 30.4 feet two days later. At Arlington the Gasconde rose in twenty-four hours 21.4 feet to a 20-foot stage, and reached a stage of 24.2 feet two days later. These stages were unprecedented for the time of year, and caused great damage in the Osage and Gasconde valleys. The town of Linn Creek, Mo., on the Osage River was completely submerged and a ferryboat plied through the principal streets carrying supplies. At Osceola, Mo., further up the same river considerable damage was also done.

Arkansas River.—The heavy rain of the 1st and 2d raised the Arkansas at Fort Smith to a navigable stage which continued during the month. The Kansas City, Pittsburg, and Gulf Railroad bridge recently constructed over the Arkansas River at Redland, 25 miles west of Fort Smith, has created such a strong current with a rising river that navigation at that point has been very greatly imperiled. The current thus created is believed to be not less than 14 miles an hour. A large quantity of driftwood and large logs of cottonwood floated down the river with the rise of the 4th and 5th. The severe cold wave which prevailed from the 25th to 29th interfered with navigation. Shore ice had formed on both banks on the morning of the 28th, and extended well into the channel on the morning of the 29th, being 6 inches thick in some places. At 5 p. m. of the 29th the ice on the north bank was broken up and dislodged, and great quantities of soft, broken ice and slush floated down the river on the 28th and 29th. An immense ice gorge, the top of which was 15 feet above the surface of the river, formed at Wilsons Rock where the river is deep and narrow. This gorge was 14 miles long and still exists, but being of a spongy nature, all apprehension of danger has been dispelled.

The rise in the river was felt at Dardanelle and Little Rock on the 3d; the maximum stage at Little Rock, 19.6 feet, occurred at 11 a. m. of the 7th when the river was within 3.4 feet of the danger line. The water began falling at Fort Smith and Dardanelle on the 7th and at Little Rock on the 8th. The river carried considerable drift from the 4th to 7th but not heavy. Light floating ice passed Little Rock on the 30th and 31st. Navigation of the upper river closed on 28th on account of ice and remained closed to the end of the month. On the lower river navigation was pursued uninterruptedly during the month. The average stage of river at Little Rock was the highest since February, 1896.

Rivers of the Pacific Coast.—The Columbia River has been open to navigation throughout the entire month. The weather being mild there was no formation of ice until the last week of the month, when a small amount was formed on the upper river but not sufficient to stop navigation. Navigation also continued on the Clear Water and Snake rivers, though the water was low but not below the average for the month. The Willamette River continued at its normal stage throughout the month; there was no ice, as there seldom is, in the Willamette.

In both the Sacramento and San Joaquin valleys the rivers continued at a moderate stage. The last two days in January there was heavy rainfall and the rivers have begun to rise rapidly. The swamp or tule lands along the Sacramento have had their basins pretty well filled with water from the various sloughs along the river. The lands which are overflowed and thereby damaged are reclaimed lands from the tule basin along the river. As a rule the large grain farms along this stream are leveed entirely by their owners, there being no regular and systematized levee system. The overflow does not necessarily cause damage because the land must have a generous soaking before it will be in a proper condition for tilling during the long, dry summer.

Heights of rivers above zeros of gauges, January, 1897.

Stations.	Distance to mouth of river.	Danger-line on gauge.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
Mississippi River.								
St. Paul, Minn.†	1,984	14	.....	.....	.....	.....	.....	.....
Reeds Landing, Minn.†	1,964	12	.....	.....	.....	.....	.....	.....
La Crosse, Wis.†	1,799	10	.....	.....	.....	.....	.....	.....
North McGregor, Iowa†	1,789	18	.....	.....	.....	.....	.....	.....
Dubuque, Iowa*	1,679	15	8.2	23	2.8	11	4.5	5.4
Leclaire, Iowa	1,589	10	.....	.....	.....	.....	.....	.....
Davenport, Iowa*	1,573	15	7.3	27	1.4	14	3.4	5.9
Keokuk, Iowa*	1,448	14	6.0	4	1.2	28	8.2	4.8
Hannibal, Mo.	1,383	17	11.0	4	0.1	28, 29	4.4	10.9
Grafton, Ill.	1,284	23	17.0	6	4.9	31	9.5	12.1
St. Louis, Mo.*	1,241	30	24.8	7	5.6	31	13.4	19.2
Chester, Ill.*	1,170	30	21.6	8	3.6	1	10.4	18.0
Cairo, Ill.	1,073	40	28.2	9	11.4	3, 4	31.7	16.8
Memphis, Tenn.	843	33	19.8	11	5.0	5	13.7	14.8
Helena, Ark.	787	37	25.8	12, 13	9.8	7	19.7	16.0
Arkansas City, Ark.	635	42	28.7	23, 30	11.8	5, 6	23.4	18.9
Greenville, Miss.	595	40	24.3	30	9.6	5, 6	18.8	14.7
Vicksburg, Miss.	474	41	26.7	31	9.7	7	19.4	17.0
New Orleans, La.	108	18	8.8	31	3.4	10	6.3	5.4
Arkansas River.								
Fort Smith, Ark.*	345	22	18.6	5	2.2	1	7.6	16.4
Dardanelle, Ark.*	260	.....	17.4	6	1.6	1, 2	7.6	15.8
Little Rock, Ark.	170	23	19.4	7	3.4	2	9.8	16.0
White River.								
Newport, Ark.	150	21	27.9	7	0.9	1	16.3	27.0
Illinois River.								
Peoria, Ill.	135	14	14.9	10, 11	5.5	1	12.7	9.4
Missouri River.								
Bismarck, N. Dak.†	1,201	14	.....	.....	.....	.....	.....	.....
Pierre, S. Dak.†	1,006	14	.....	.....	.....	.....	.....	.....
Sioux City, Iowa†	676	19	.....	.....	.....	.....	.....	.....
Omaha, Nebr.*	561	18	10.1	27, 28	5.2	4	9.1	4.9
Kansas City, Mo.	380	21	9.7	31	6.5	1-4, 27	7.5	3.2
Boonville, Mo.	191	30	10.2	31	3.7	31	6.8	6.5
Hermann, Mo.*	95	21	14.3	4	1.0	1	7.1	13.3
Ohio River.								
Pittsburg, Pa.	906	22	7.3	7	2.3	25	4.2	5.0
Davis Island Dam, Pa.	980	25	8.5	7	4.0	28	6.0	4.5
Wheeling, W. Va.*	875	36	9.9	8	5.4	16	7.5	4.5
Martetta, Ohio†	795	26	10.3	8	5.8	17	8.2	4.5
Parkersburg, W. Va.	755	38	10.5	8, 9	6.8	17, 18	8.8	3.7
Point Pleasant, W. Va.†	703	36	10.8	23	3.0	31	7.8	7.8
Catlettsburg, Ky.	651	50	.....	.....	.....	.....	.....	.....
Portsmouth, Ohio	612	50	.....	.....	.....	.....	.....	.....
Cincinnati, Ohio	492	45	17.8	25	9.3	3	14.4	8.5
Louisville, Ky.†	397	24	8.1	25	5.4	4	6.9	2.7
Evansville, Ind.	184	30	15.9	23	6.8	5	11.5	8.1
Mount Vernon, Ind.†	35	35	16.5	23, 24	6.5	5	8.7	10.0
Paducah, Ky.	47	40	19.8	24	6.5	3, 4	13.5	13.3
Allegheny River.								
Warren, Pa.	177	7	3.5	6	0.9	15-18, 29-31	1.5	2.6
Oil City, Pa.	123	13	3.8	6	1.8	1, 30, 31	2.4	2.0
Parker, Pa.	73	20	4.0	8	1.4	1	2.5	2.6
Freeport, Pa.	26	30	7.0	7	2.9	15	4.7	4.1
Conemaugh River.								
Johnstown, Pa.*	64	7	2.6	5	1.2	16	1.7	1.4
Red Bank Creek.								
Brookville, Pa.	35	8	.....	.....	.....	.....	.....	.....
Beaver River.								
Ellwood Junction, Pa.	10	14	2.8	1-6	1.8	30, 31	2.2	1.0
Big Sandy River.								
Louisia, Ky.	26	20	6.9	24	3.3	13, 14	4.9	3.6

Heights of rivers above zeros of gauges—Continued.

Stations.	Distance to mouth of river.	Danger-line on gauge.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
<i>Cumberland River.</i>	Miles.	Feet.	Feet.		Feet.		Feet.	Feet.
Barnside, Ky.....	434	50	18.0	15	0.8	3	5.1	17.2
Carthage, Tenn.....	257	30	15.9	18	2.0	3	6.8	18.9
Nashville, Tenn.....	175	60	20.9	18	3.0	3	10.1	17.9
<i>Great Kanawha River.</i>								
Charleston, W. Va.....	61	30	5.8	23	3.2	20-31	5.0	2.6
<i>New River.</i>								
Radford, Va.....	153	14	1.0	23, 23	0.3	13, 14	0.5	0.7
Hinton, W. Va.....	98	14	2.6	23, 24	1.1	30, 31	1.9	1.5
<i>Licking River.</i>								
Falmouth, Ky.....	30	25	6.5	21	1.6	11-14	2.9	4.9
<i>Miami River.</i>								
Dayton, Ohio.....	69	18	2.8	5	1.2	2, 3	1.6	1.6
<i>Monongahela River.</i>								
Weston, W. Va.....	161	18	1.5	5	0.0	(1-4, 8-20) (26-28)	0.2	1.5
Fairmont, W. Va.....	119	25	4.4	19	1.3	15, 16	2.2	8.1
Morgantown, W. Va. P.....	95	20	10.0	19	7.5	14, 15	8.3	2.5
Greensboro, Pa.....	81	18	10.5	19, 30	7.6	31	8.6	2.9
Lock No. 4, Pa.....	40	28	10.8	19, 30	6.7	29-31	8.4	4.1
<i>Cheat River.</i>								
Rowlesburg, W. Va.....	36	14	5.5	18	2.4	1	2.4	3.1
<i>Youghiogheny River.</i>								
Confluence, Pa.....	59	10	3.9	5, 18	1.5	16, 30	2.4	2.4
West Newton, Pa.....	15	23	3.4	23	1.0	1, 2, 16, 17	2.0	2.4
<i>Tennessee River.</i>								
Knoxville, Tenn.....	614	29	2.5	15, 16, 18	0.8	3, 10-13	1.7	1.7
Chattanooga, Tenn.....	430	33	7.3	23	2.4	1, 13	4.4	4.9
Bridgeport, Ala.....	330	.....	5.6	23, 23	1.1	1-4	2.9	4.5
Florence, Ala.....	220	16	6.5	23	1.0	3	3.3	5.5
Johnsonville, Tenn.....	94	21	10.6	23, 23	2.6	4	5.8	8.0
Rockwood, Tenn.....	519	20	6.1	23	1.7	12, 13	3.4	4.4
<i>Wabash River.</i>								
Terre Haute, Ind.....	165	16	14.5	6, 7	1.7	1	8.7	12.8
Mt. Carmel, Ill.....	50	15	13.9	23	2.9	2	9.7	11.0
<i>Red River.</i>								
Arthur City, Tex.....	688	27	20.6	4	2.6	1	6.0	18.0
Fulton, Ark.....	565	28	21.8	7	1.2	1, 2	10.0	20.6
Shreveport, La.....	449	29	10.0	11	-1.8	1.2	6.8	11.8
Alexandria, La.....	139	33	15.0	21, 23	-0.9	1	9.7	15.9
<i>Atchafalaya River.</i>								
Melville, La.....	100	31	25.0	31	13.2	1	19.9	11.8
<i>Ouachita River.</i>								
Camden, Ark.....	340	39	30.5	8	4.1	1	19.3	26.4
Monroe, La.....	100	40	24.6	30, 31	2.8	1	18.7	21.8
<i>Yazoo River.</i>								
Yazoo City, Miss.....	80	26	7.6	31	-1.8	1, 2	3.8	9.4
<i>Tombigbee River.</i>								
Columbus, Miss.....	235	33	6.0	19	-2.7	1	0.7	8.7
Demopolis, Ala.....	155	35	20.6	22	-0.9	1-3	7.1	21.5
<i>Black Warrior River.</i>								
Cordova, Ala.....	155	20	11.7	18	2.2	1-3	4.8	9.5
Tuscaloosa, Ala.....	90	33	19.3	19	0.3	1	6.5	19.0
<i>Alabama River.</i>								
Montgomery, Ala.....	265	35	13.0	22	0.4	3, 3	3.7	12.6
Selma, Ala.....	312	35	14.8	23	0.2	1, 2, 15-17	4.0	14.6

Heights of rivers above zeros of gauges—Continued.

Stations.	Distance to mouth of river.	Danger-line on gauge.	Highest water.		Lowest water.		Mean stage.	Monthly range.
			Height.	Date.	Height.	Date.		
<i>Coosa River.</i>	Miles.	Feet.	Feet.		Feet.		Feet.	Feet.
Rome, Ga.....	225	30	9.5	23	0.9	11-13	2.9	8.6
<i>Wilsonville River.</i>								
Wilsonville, Ala.....	66	15	.....	.....	.....	.....	.....	.....
<i>Tallapoosa River.</i>								
Sturdevant, Ala.....	69	15	.....	.....	.....	.....	.....	.....
<i>Savannah River.</i>								
Augusta, Ga.....	130	32	20.8	22	5.8	13	9.0	15.0
<i>Edisto River.</i>								
Edisto, S. C.....	75	6	4.7	23	2.4	12, 13	3.4	2.3
<i>Congaree River.</i>								
Columbia, S. C.....	37	15	7.0	23	0.8	3, 8-13	2.2	6.2
<i>Santee River.</i>								
St. Stephens, S. C.....	50	12	7.8	31	2.0	14	4.5	5.8
<i>Watauga River.</i>								
Camden, S. C.....	45	24	18.0	22	3.1	8	5.7	14.9
<i>Black River.</i>								
Kingstree, S. C.....	60	12	6.6	30, 31	3.3	14	5.2	3.3
<i>Great Pee Dee River.</i>								
Cheraw, S. C.....	145	27	21.4	23	1.8	13	4.3	19.6
<i>Lynch Creek.</i>								
Effingham, S. C.....	35	12	7.6	30	4.4	13	5.5	3.9
<i>Lumber River.</i>								
Fairbluff, N. C.....	10	6	4.0	1	2.9	31	3.2	1.1
<i>Waccamaw River.</i>								
Conway, S. C.....	40	7	5.3	1	2.2	17	3.4	3.1
<i>Cape Fear River.</i>								
Fayetteville, N. C.....	100	38	24.0	23	4.0	13	7.7	20.0
<i>James River.</i>								
Lynchburg, Va.....	257	18	1.0	23, 23	0.4	1-4, 10-13	0.6	0.6
<i>Potomac River.</i>								
Richmond, Va.....	110	10	.....	.....	.....	.....	.....	.....
<i>Harpers Ferry River.</i>								
Harpers Ferry, Md.....	170	16	.....	.....	.....	.....	.....	.....
<i>Susquehanna River.</i>								
Wilkesbarre, Pa.....	178	14	.....	.....	.....	.....	.....	.....
<i>Harrisburg River.</i>								
Harrisburg, Pa.....	70	17	3.7	7-9	0.5	26	2.5	3.2
<i>W. Br. of Susquehanna.</i>								
Lock Haven, Pa.....	63	.....	2.0	8	0.5	27-31	1.1	1.5
<i>Williamsport River.</i>								
Williamsport, Pa.....	35	20	3.9	6	1.4	21	2.3	2.5
<i>Juniata River.</i>								
Huntingdon, Pa.....	80	24	4.9	5	3.4	23-31	3.6	1.5
<i>Sacramento River.</i>								
Redbluff, Cal.....	241	23	14.0	20	2.0	20-27	4.1	12.0
<i>Sacramento River.</i>								
Sacramento, Cal.....	70	28	20.0	31	14.5	28, 29	16.3	5.5
<i>Willamette River.</i>								
Eugene, Ore.....	149	10	7.6	1	3.2	17	4.5	4.4
Albany, Ore.....	99	20	10.8	2	4.2	18	6.0	6.6
Salem, Ore.....	69	20	9.6	1	7.4	16, 26	8.1	2.2
Portland, Ore.....	10	15	8.7	3	3.0	15, 16	5.5	5.7

*Distance to the Gulf of Mexico. †Frozen. ‡Frozen 29-31. §Frozen 26-31. ¶Frozen 29-31. ††Frozen 26, †††Frozen 29. ††††Frozen 30-31. †††††Frozen 28-31. ††††††Frozen 5-9. †††††††Frozen 26-31. ††††††††Frozen 26-31. †††††††††Frozen 23-31. †††††††††Frozen 25-31. ††††††††††Frozen 28-31. ††††††††††Frozen 29-31. †††††††††††Frozen 13, 25-31. †††††††††††Frozen 25. ††††††††††††Frozen 15, 16, 25, 31. †††††††††††††Frozen 25-31. †††††††††††††Frozen 29-31. †††††††††††††Frozen 26-31. †††††††††††††Frozen 31. ††††††††††††††No observation 15-18.

SPECIAL CONTRIBUTIONS.

CLOUD OBSERVATIONS AND MEASUREMENTS AT THE BLUE HILL METEOROLOGICAL OBSERVATORY, MILTON, MASS.

Communicated by A. LAWRENCE ROTCH, Director (dated February 23, 1897).

Nephoscope observations of direction and relative velocity are made on Blue Hill three times a day in cooperation with the network of stations of the United States Weather Bureau. Nephoscope observations have been made on Blue Hill three times a day, or oftener, since 1887.

There are three theodolite stations in the same straight line, furnishing three bases, respectively of 2,590 meters, 1,178 meters, and 1,412 meters, from the ends of some one of which simultaneous observations for height and velocity are made twice a day when conditions permit. These observations were re-commenced May 1, 1896, and have been obtained on about eighty days in each one hundred. The differences in level between the ends of the base lines are 189, 126, and 63 meters, in the order given above. Two of the theodolites are similar to those first used by Mohn for measuring auroras, and the third theodolite is a surveyor's transit remodeled to conform to this pattern. In making observations, points on the clouds are selected by telephonic communication, and, when practicable, from three to five observations are taken on the same point, at intervals of a minute. Three or more

points are selected successively on the same kind of clouds, in different parts of the sky, in order to avoid the error which may arise from the observers at the same moment following different clouds or different portions of the same cloud, and also in order to obtain a better knowledge of the mean height of the same cloud stratum.

The observations are reduced by the simple trigonometrical formulæ. All poor observations are discarded, as well as those made when the cloud was near the horizon or near the base line.

The theodolite measurements at two stations are supplemented by four other methods, devised by Mr. Clayton, to determine the height of the lower clouds; these are:

1. Measurements at one station of the positions of the cloud, sun, and cloud shadow from which the height can be calculated.
 2. Sending up kites and measuring the amount of line and the angle of the kite above the horizon when it enters the base of the cloud.
 3. Measuring from Blue Hill, the angular altitude of light reflected at night on clouds above cities whose distances are known.
 4. Noting the height of the base of low clouds on the side of Blue Hill.
- The first two methods are used frequently, the last two only